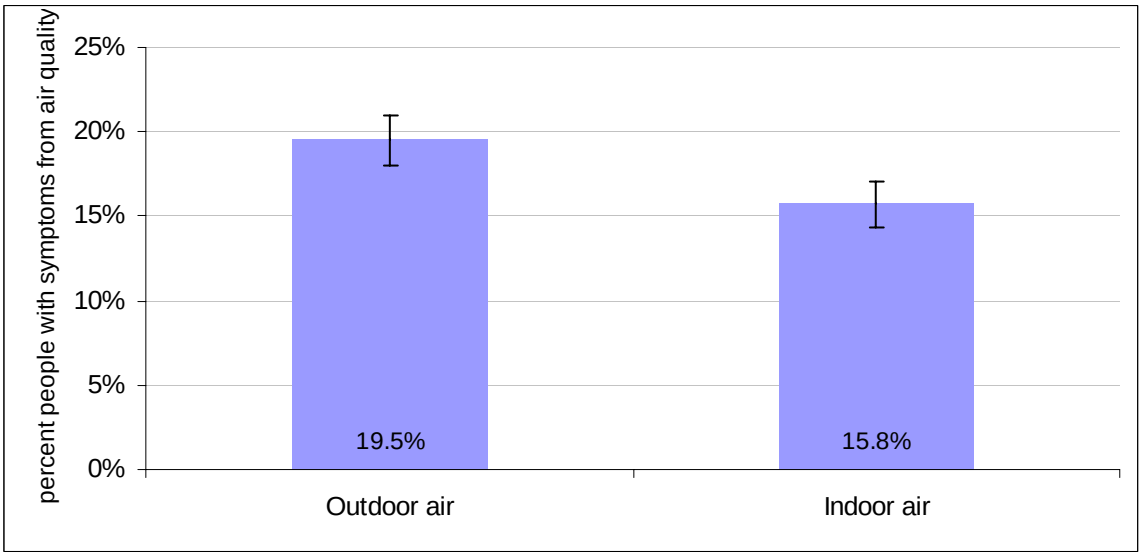
VII. Environmental Risk Factors for Asthma

Environmental and occupational exposures contribute to illness and disability from asthma. Some individuals are more vulnerable to asthma due to individual risk factors (previously discussed in chapters IV and V), and some exposures have only been proven to cause or trigger asthma within certain vulnerable population groups (such as children) or under certain conditions (dose levels).

Environmental asthma controls are an essential complement to clinical asthma controls. For example, a child with asthma can obtain the best quality of medical care possible, but if she sleeps every night in a bed filled with dust mites, and has pets that sleep in the bed beside her, then her symptoms may remain if either of those is a trigger for her.

In 1996, Washington adults were asked as part of a statewide survey whether they had experienced symptoms or discomfort such as headaches, coughing or difficulty breathing as a result of indoor or outdoor air quality. At that time, significantly more adults reported symptoms from outdoor air exposure than from indoor air exposure (19.5% vs. 15.8%, see Figure 73).

Figure 1: Prevalence of symptoms/discomfort as a result of air quality, among Washington adults



Source: Washington State BRFSS 1996

In fact, there are a number of exposures in both outdoor and indoor air that can affect the health of Washington residents, specifically some exposures are known to cause asthma or trigger asthma attacks.

Proven Exposures

New research is constantly published to describe associations between exposure to specific agents or groups of agents related to health outcomes. Sometimes different studies have conflicting results. For the purpose of identifying and discussing specific exposures that affect asthma within this report only major review reports and a few key studies (including from Washington State) were considered. Only agents cited in reviews that were identified as having at least "sufficient cause of association" for asthma are included in this discussion; these are agents where multiple studies have observed relationships between the exposure and the outcome (causing or exacerbating asthma) where chance, bias, and confounding can be ruled out with reasonable confidence.

The threshold of "proof" chosen for this report is conservative and likely excludes real environmental causes and triggers of asthma identified in more recent articles and reviews; however, the purpose of selecting exposures for description is to frame the discussion about what specific information is available to describe exposures in Washington, not to provide an exhaustive review of the literature or recommend which agents should be prioritized for action.

Outdoor Exposures

Agents that are known to cause or aggravate asthma include the following.[i,ii]

Table 2: Outdoor air exposures that cause or trigger asthma

Pollutant	Source	Effect on Asthma
Ozone	Principal component of urban smog, usually greatest on hot summer days. Formed when vehicle and industrial emissions react with sunlight.	Exposure associated with asthma development among children frequently playing outdoor sports. Exposure increased symptoms and emergency room visits among people with asthma.[iii]
Fine particulate matter (PM)	Easily inhaled tiny particles including dirt, soot, dust, smoke or unburned fuel, and aerosols suspended in the air that come from mobile vehicles – especially diesel exhaust, construction, mining, wood smoke, fireplace or backyard burning, agricultural burning, wildfires and industry.	Exposure increased symptoms and emergency room visits among people with asthma, decreased lung function.[iv,v.vi,viii]
Carbon Monoxide	Combustion, including motor vehicles and woodsmoke	Exposure increased symptoms among people with asthma.[iv,v]
Nitrogen oxides (NO_X)	Fuel emissions from mobile sources such as cars or trucks and also power plants.	Exposure increased symptoms among people with asthma.
Sulfur dioxide (SO_2)	Typically from industrial sources, such as power plants, that burn sulfur-containing fuels like coal and oil. Mt. St. Helens is also a periodically significant source of SO_2 in Washington State.	Exposure increased symptoms among people with asthma.

Polluted outdoor air, such as from particulate matter (PM) and ozone, can cause or worsen lung-related diseases, such as emphysema, chronic bronchitis and asthma.[vii] Diesel exhaust from mobile vehicles is of particular concern as an air toxic, as it has been identified as a probable cause of cancer, an allergen and also an asthma trigger.

Air pollution exposure reduces lung function and lung growth in children.[viii] Children with asthma have been observed to have more lower respiratory tract symptoms on days with poor air quality,[ix] and a study conducted in Seattle found that days with increased air pollution (measured as particulate matter and carbon monoxide from combustion sources such as cars, trucks, boats, or woodstoves) increased children's symptoms for asthma even though average concentrations were better than the National Ambient Air Quality Standard.[x] A longitudinal study of children in California found that children's lung

function decreased with regard to outdoor air pollution (PM^{10} and Nitrogen oxides).[xi] A follow-up of children in the California study who had moved from the original community found that children who moved to communities with less polluted air than their original community had increased growth in lung function while children who had moved to more polluted communities had decreased growth in lung function.[xii] The same study found children in areas with high ozone and who frequently played outdoor sports developed asthma more often than children who lived in areas with lower ozone and those who lived there but did not frequently play outdoor sports.[xiii,xiv]

People, particularly children, with asthma have been observed to have increased emergency department visits for asthma as a direct result of poor air quality.[xv] A Seattle study also found that on days with higher air pollution children's emergency department visits for asthma were increased.[xvi]

The Environmental Protection Agency (EPA) "Air Quality Index" (AQI) is a single air quality measure created by combining data from ambient air monitoring for a number of pollutants. EPA calculates the AQI for five major air pollutants regulated by the Clean Air Act: ground-level ozone, particle pollution (also known as particulate matter), carbon monoxide, sulfur dioxide, and nitrogen dioxide.[xvii] It is important for sensitive populations (including people with asthma) and organizations responsible for protecting groups of people who may be affected (including schools and daycare centers) to check the EPA Air Quality Index on a daily basis to determine whether outdoor air quality is likely to affect their asthma.

National Objectives

Healthy People 2010 includes a number of environmental health objectives for improving air quality to benefit general health. These objectives were not specifically identified for asthma, but to improve respiratory health more generally, and text of the objectives has been modified to be specific to the asthma-related content. Washington data were not currently available to measure achievement of these goals.

Healthy People 2010 Objective 8-1
Reduce the proportion of persons exposed to air that does not meet the Environmental Protection Agency's health-based standards for harmful air pollutants

Target: Zero percent of the population exposed to

- Ozone – by year 2012
- Particulate Matter (PM) – by year 2018
- Carbon Monoxide
- Nitrogen Dioxide
- Sulfur Dioxide

Healthy People 2010 Objective 8-2
Increase use of alternative modes of transportation to reduce motor vehicle emissions and improve the Nation's air quality.

Target:

- Trips made by bicycling – 1.8%
- Trips made by walking – 10.8%
- Trips made by transit – 3.6%
- Persons who telecommute - developmental

Healthy People 2010 Objective 8-3
Improve the Nation's air quality by increasing the use of cleaner alternative fuels.

Target: 30% of US fuel consumption

Healthy People 2010 Objective 8-4
Reduce air toxic emissions to decrease the risk of adverse health effects caused by airborne toxics.

Target: 20 million tons (released annually in US)

Indoor Exposures

Indoor air exposures may be more easily modified than outdoor exposures. People can make changes to immediately improve indoor air in worksites, schools and homes. Indoor air quality, however, is influenced by outdoor air quality because outdoor air is drawn indoors continually.

Table 3 summarizes reviews of the evidence for indoor air exposures that can influence asthma that have been published by the Institute of Medicine and others. **Error! Bookmark not defined.**[xviii,i] If an agent or chemical was found to have "sufficient cause" as an asthma trigger, then information is also presented about findings of association as a cause of asthma even if the evidence is limited (e.g. indoor chemical exposures or dampness).

Table 3: Indoor air exposures proven to cause or trigger asthma

Indoor Air Exposure	Cause of Asthma	Trigger of Asthma (Exacerbation)
Dust Mite Allergen	XXX	XXX
Cockroach Allergen	XX*	XXX
Dog Allergen		XX
Cat Allergen		XXX
Fungi/Mold		XX
Secondhand Tobacco Smoke	XX*	XXX
Indoor Chemical Exposures (Fragrances, non-specific exposures)	X	XX
Dampness Indoors/Home	X	XX
NO_2 (e.g. gas appliances in poorly ventilated kitchens)		XX

Table Key: * among young children only

X = Limited evidence for association; XX = Sufficient evidence for association; XXX = Sufficient evidence for causation

Source: Institute of Medicine reports,**Error! Bookmark not defined.**,[xviii] updated using Etzel.

Some of the exposures indicated could be easily reduced or modified in environments. Pets can be removed from the household or at least restricted from certain parts of the house, smoking can be banned indoors and near entryways or air intake systems, and fragrance-free products (including cleaning agents) can be used.

Reduction of dust mites and cockroaches may be more difficult. Dust mites are tiny creatures of microscopic size (similar to spiders or ticks) that live in bedding or other soft materials and feed on the dead skin that falls from people and animals, thus good cleaning and removal of habitat (e.g., dust covers on mattresses, removal of carpeting, stuffed animals from children's rooms).

Routine cleaning practices can help control cockroaches, but these pests can survive even in clean homes. Approaches to control may include making sure homes are structurally sealed to prevent re-entry and not leaving food or water out.

Indoor air dampness and mold control requiring both cleaning and structural solutions, which can be intensive. Homes should be sealed and checked to assure that water is not seeping in, plumbing is not leaking, and ventilation should be checked to assure that dampness indoors is vented out (bathrooms, kitchens). Maintaining good ventilation is also important for controlling emissions from gas appliances, and includes simply checking that existing fans are working properly and turned on as needed. Wood-burning stoves should be EPA certified and stoves/fire places should be maintained and chimneys inspected to make sure they are functioning properly; whenever possible alternative sources of heat such as gas or electric should be used

Secondhand smoke is a notable exposure that is present in both home and some worksite settings. Exposure to secondhand smoke exacerbates asthma in a number of ways. In a variety of studies, exposed children with asthma had a more frequent need for emergency services,**Error! Bookmark not defined.** a greater need for medications,**Error! Bookmark not defined.** and a more difficult time recovering from an acute asthmatic episode.[xix] [xx] Much of the literature has focused on secondhand smoke exposure and childhood asthma, however a number of studies have linked secondhand smoke exposure with adult-onset asthma.**Error! Bookmark not defined.** [xxi] [xxii] [xxiii] [xxiv] [xxv] A recent study by Jaakola and colleagues[xxvi] was the first to report that both cumulative lifetime and recent exposures increase the risk of asthma, in both the home and workplace. In this study, exposure in the past year at workplaces increased the risk over twofold, and at home almost fivefold. The authors also calculated that almost 50% of new adult asthma cases occurring among adults exposed to secondhand smoke during the past year were attributable to that exposure.

According to the criteria established by the Association of Occupational and Environmental Health Clinics for designating substances as work-related asthmagens, there are currently over 350 substances known to cause asthma in the workplace. These include chemicals, dusts, metals, plant and animal materials, and proteins, among others.[xxvii]

National Objectives for Indoor Air

The national objectives listed below were included in the Environmental Health chapter for Healthy People 2010 to promote "Healthy Homes and Healthy Communities". Washington data were not available at this time to measure relative status for these objectives.

Healthy People 2010 Objective 8-16
Reduce indoor allergen levels.

Target: expressed as "percent of homes"

- Group I dust mite allergens that exceed 2 micrograms per gram of dust in the bed – 29.0%
- Group I dust mite allergens that exceed 10 micrograms per gram of dust in the bed – 14.9%
- German cockroach allergens that exceed 0.1 microgram per gram of dust in the bed – 3.8%

Healthy People 2010 Objective 8-17
Increase the number of office buildings that are managed using good indoor air quality practices.

Target: Developmental

Healthy People 2010 Objective 8-20
Increase the proportion of the Nation's primary and secondary schools that have official school policies ensuring the safety of students and staff from environmental hazards, such as chemicals in special classrooms and poor indoor air quality.

Target: Developmental

(original objective text includes asbestos and pesticides, not specifically linked to asthma)

Healthy People 2010 Objective 8-23
Reduce the proportion of occupied housing units that are substandard.

Target: 3%

A. Communities

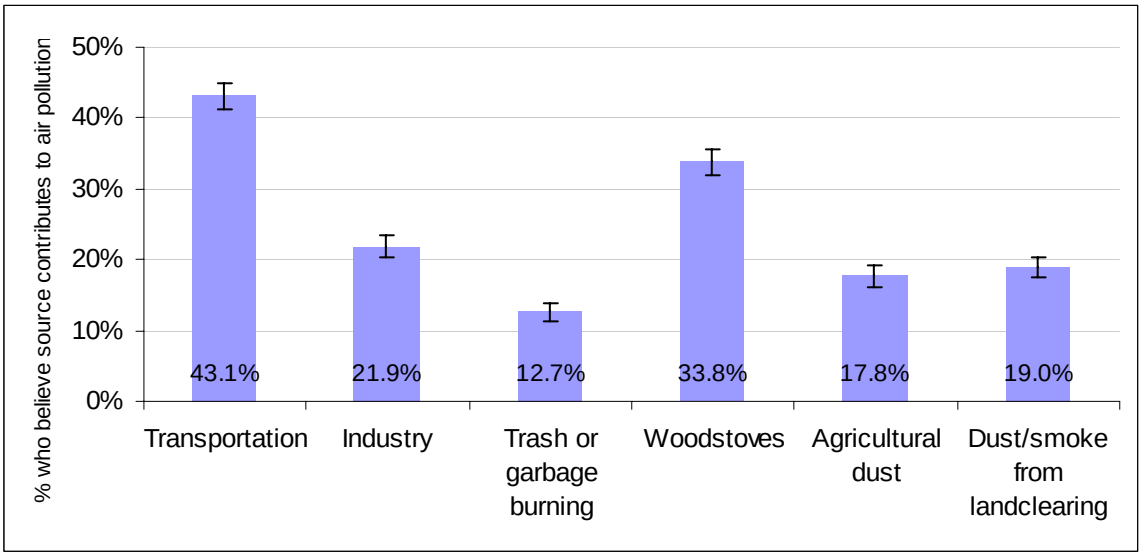
This section describes what is known about air quality in our communities – the state, counties, cities and other geographic areas where people live.

Outdoor/Ambient Air

Washington adults report believing that outdoor air contributes to asthma. A national poll conducted in 2000 that included more than 800 registered voters from Washington State found that 57% believe that environmental factors play a major role in causing asthma among children and an additional 27% believe that environmental factors play a minor role in causing asthma among children.[xxviii] In the study, Washington adults ranked asthma as second among health conditions that they perceived the environment has a major role in causing (behind allergy and sinus problems).

As part of the Washington BRFSS adults were asked about what sources they believe contribute to outdoor air pollution. Transportation and woodstoves were identified as most commonly believed to be outdoor air pollution contributors, followed by industry, dust/smoke and agricultural dust, and trash or garbage burning were perceived as having the least impact (see Figure 74).

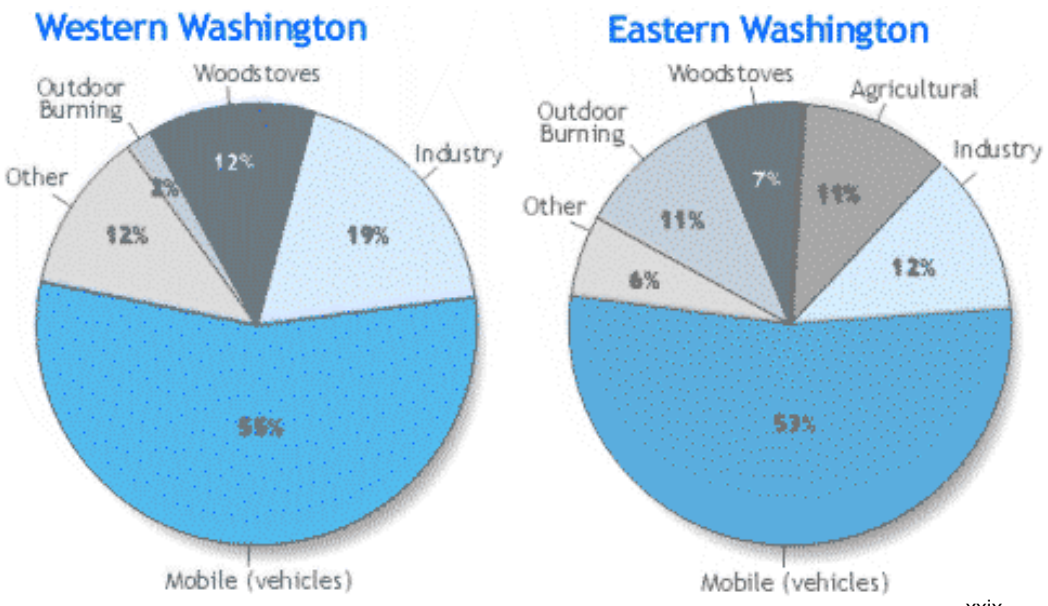
Figure 2: Prevalence of belief about contributors to outdoor air pollution, among Washington adults



Source: Washington State Behavioral Risk Factor Surveillance System (BRFSS) 1996

Findings from these attitudinal reports are not inconsistent with actual factors identified by the Department of Ecology as contributing to poor air quality as particulate matter (see Figure 75). The primary cause of poor air quality in Washington is mobile vehicle exhaust. There are some differences in actual sources of pollutants between Eastern and Western Washington. In Eastern Washington agricultural practices and outdoor burning are leading contributors to poor air quality, while in Western Washington woodstoves and industry are comparatively more important.

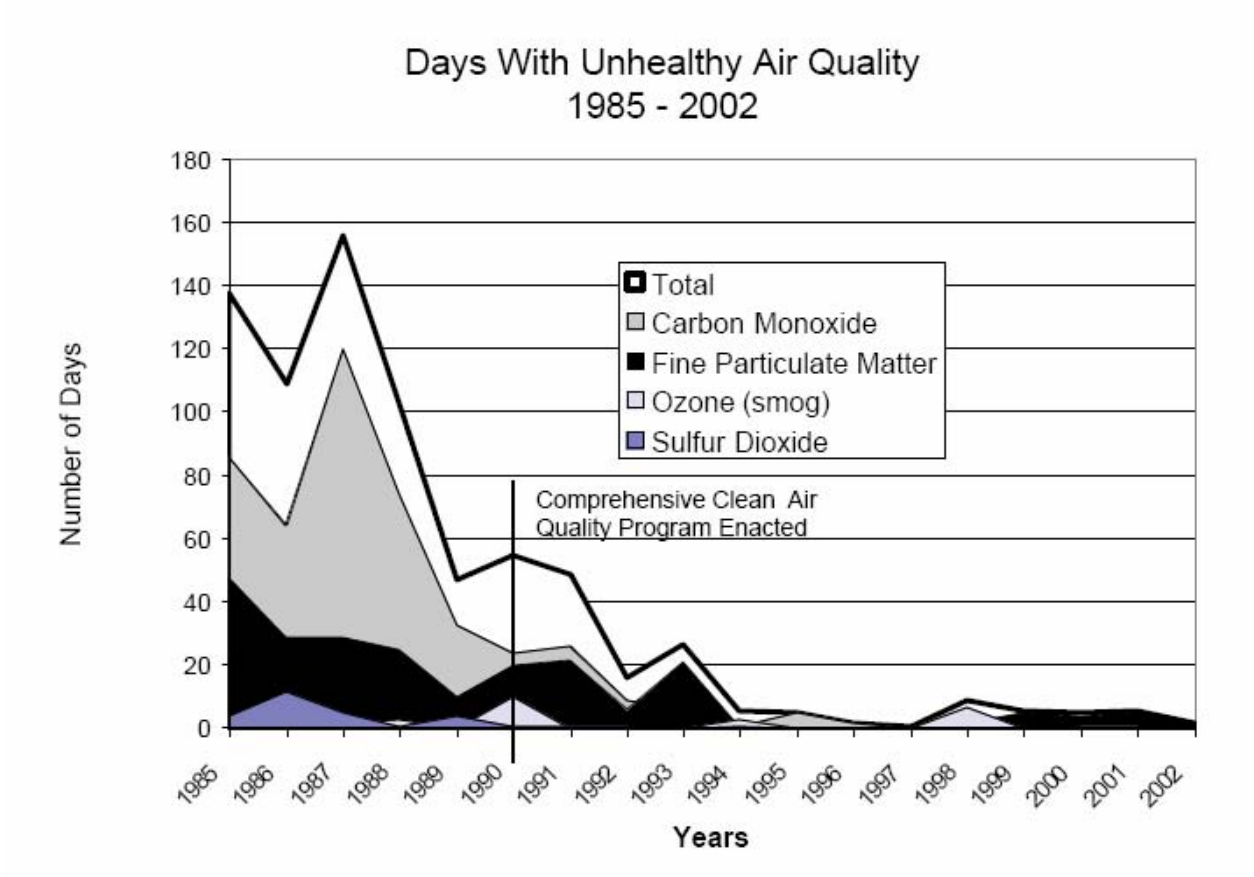
Figure 3: Factors that contribute to poor air quality in Washington State



Source: Washington State Department of Ecology, Environmental Health in Washington State 2000[xxix]

Washington's outdoor air quality is generally considered moderate to good. The air quality has improved over the last ten years as measured by the number of days that air quality in Washington did not meet health standards for carbon monoxide, particulate matter, ground-level ozone and sulfur dioxide for the state overall (see Figure 76). Substantial improvement has been made overall since implementation of clean air policies in the early 1990s; however, fine particulate matter were not decreased in 2000-2002. Our growing population and the miles we travel by car continue to threaten the quality of our air.

Figure 4: Trends for "unhealthy air quality days" in Washington State

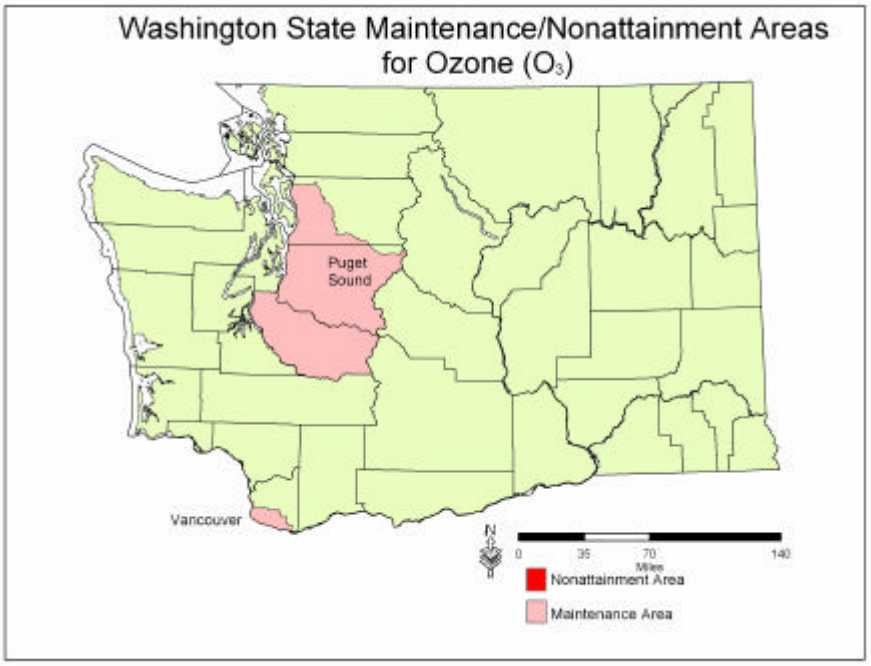


Source: Washington State Department of Ecology, April 2003[xxx]

Specific programs, such as those to encourage retrofit of diesel vehicles, including school buses, to reduce particulate matter,[xxxi] will contribute to continued improvement in outdoor air quality.[1] Despite progress in achieving clean outdoor air statewide, specific geographic areas remain at increased risk for poor air quality. For example, the Puget Sound region and Vancouver remain areas of concern for ozone (see Figure 77). Spokane, Yakima, and Wallula are all out of attainment for PM, and the Kent Valley, Seattle Duwamish, Tacoma Tideflats, and Thurston County are all in maintenance (see Figure 78). For people with severe asthma in these communities in particular, it may be important to monitor air quality on a daily basis and modify outdoor activities accordingly.

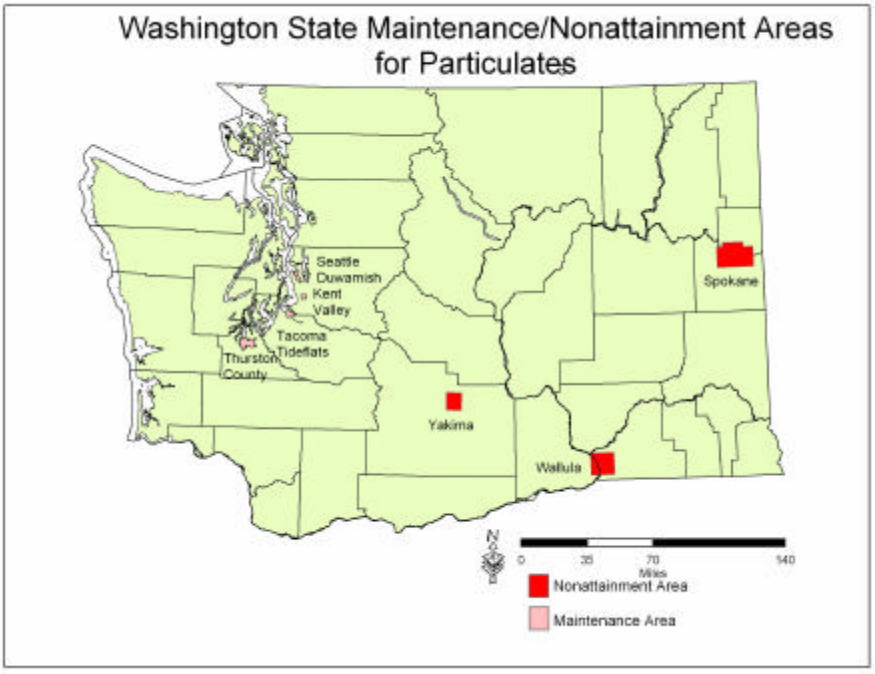
[1] EPA regulations require that by 2007 new diesel engines must meet lower vehicle emission standards, however this will not affect vehicles that are already on the road

Figure 5: Maintenance/nonattainment areas for ozone in Washington State



Source: Washington State Department of Ecology

Figure 6: Maintenance/nonattainment areas for particulate matter (PM) in Washington State



Source: Washington State Department of Ecology

Indoor Air

The primary concern for communities is ambient, or outdoor air. This means the general air in a geographic area. Community leaders can play a role in improving indoor air environments by providing education or creating and enforcing rules that assure clean indoor air quality in buildings that serve the public. Specifically, communities can work to improve indoor air quality in worksites (general exposures, such as secondhand smoke, rather than specific occupational exposures), government buildings and libraries, daycare facilities, churches or worship settings, and group home facilities. Discussion in the following sections on worksites and homes are relevant to these potential efforts.

B. Schools

Indoor Air

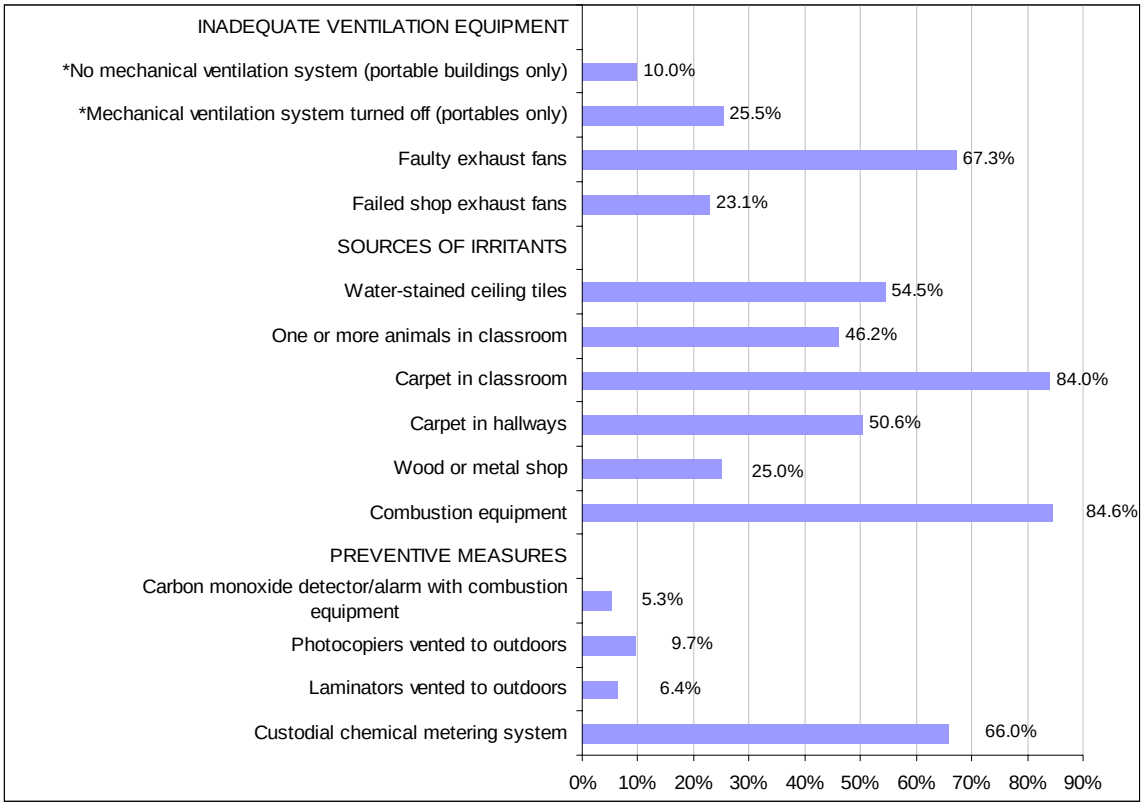
Facilities and practices within school buildings can have a substantial effect on air quality. A survey of several thousand classrooms in Washington and Idaho public schools (3,801 total classrooms, with about 5% of these rooms in "portable" or "relocatable" buildings) found that a substantial proportion of school buildings had risk factors for poor air quality, and only a few had protective measures in place (see Figure 79).[xxxii]

About one in four "portable" buildings had turned off their ventilation systems (presumably because of noise). Two-thirds of school buildings had faulty exhaust fans. Other common sources of asthma-related pollutants in these school buildings included evidence of dampness (water stains on ceiling tiles in 54% of buildings), sources of animal dander allergens, carpeting which can harbor dust mites, pollens or mold, and sources of chemical irritants. Most prevalent were classroom carpets and combustion equipment.

Very few school buildings had protective measures in place to assure that sources of pollution were minimized. Fewer than 10% had ventilation of copiers or laminators to the outdoors. Less than one in twenty schools had a carbon monoxide alarm located around combustion equipment.[2]

[2] Carbon monoxide in this case is not a trigger for asthma, but a marker for poor function of ventilation equipment (leaking of fuel or incomplete burning of fuel)

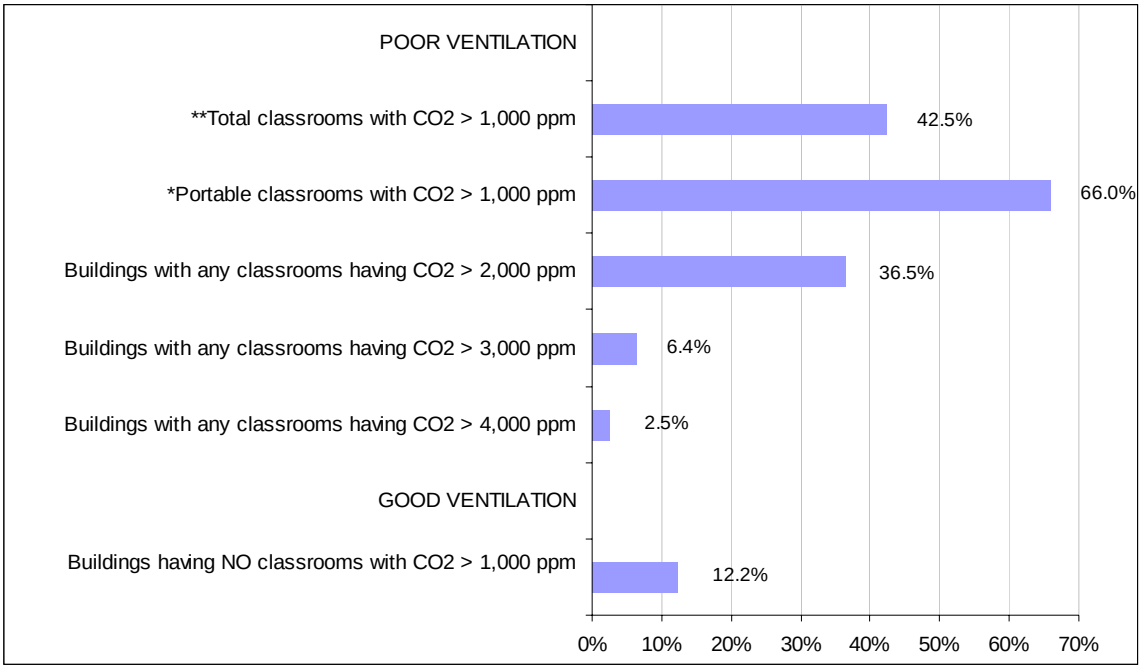
Figure 7: Prevalence of risk factors for poor indoor air quality, among Northwest schools



Source: Washington and Idaho schools included in Prill et al. [Note: Measures marked * are of portable classrooms; remaining percentages are for school buildings, not classrooms.]

The same study in Washington and Idaho public schools found that that nearly half of the classrooms monitored had short-term measures of poor air quality, using carbon dioxide concentration – CO_2 parts per million -- as a proxy for air quality (see Figure 80). Further research in a subset of these schools found that reduced outside air ventilation, indicated by elevated carbon dioxide concentrations, was associated with 10-20% increases in student absence.[xxxiii] The reduced attendance was observed among the general student population, thus maintaining good indoor air quality is important in supporting the educational success of all students, not only important for students with asthma.

Figure 8: Prevalence of poor indoor air quality, among Northwest schools



Source: Washington and Idaho schools included in Prill et al. [Note: Measures marked * for portable classrooms and ** for total classrooms; remaining percentages are for buildings.]

Ambient Air Surrounding Schools

As discussed previously, mobile vehicles – including school buses and vehicles driven by students, parents and staff – are among the major contributors to air pollution. Data to specifically measure outdoor air quality surrounding schools are not available, however a five-year program was authorized by the 2003 State Legislature[3] to retrofit diesel bus engines in 7,500 diesel school buses (about three-quarters of the existing fleet) by 2008. Some Washington schools have additionally instituted "No Idle Zone" campaigns to reduce emissions from both buses and parents waiting for students. The average idling time of motor vehicles was reduced around schools that participated in pilot anti-idling campaign.[xxxiv] Data are not yet available to describe the air quality or health outcome improvements expected as a result of these programs.

C. Worksites

Occupational Exposures

Recent studies in the U.S. have found that in working adults, between 10 and 26 percent of new onset asthma is attributable to work-related asthma.[xxxv] [xxxvi] Occupational factors cause or trigger asthma episodes in 5 to 30 percent of adults with the disease. [xxxvii]

Depending on the type and intensity of work exposures, the frequency of work-related asthma may be very high in some industrial settings (e.g., about 25 percent in one group of platinum-refinery workers); in other industries, only sporadic cases may be reported.[xxxviii]

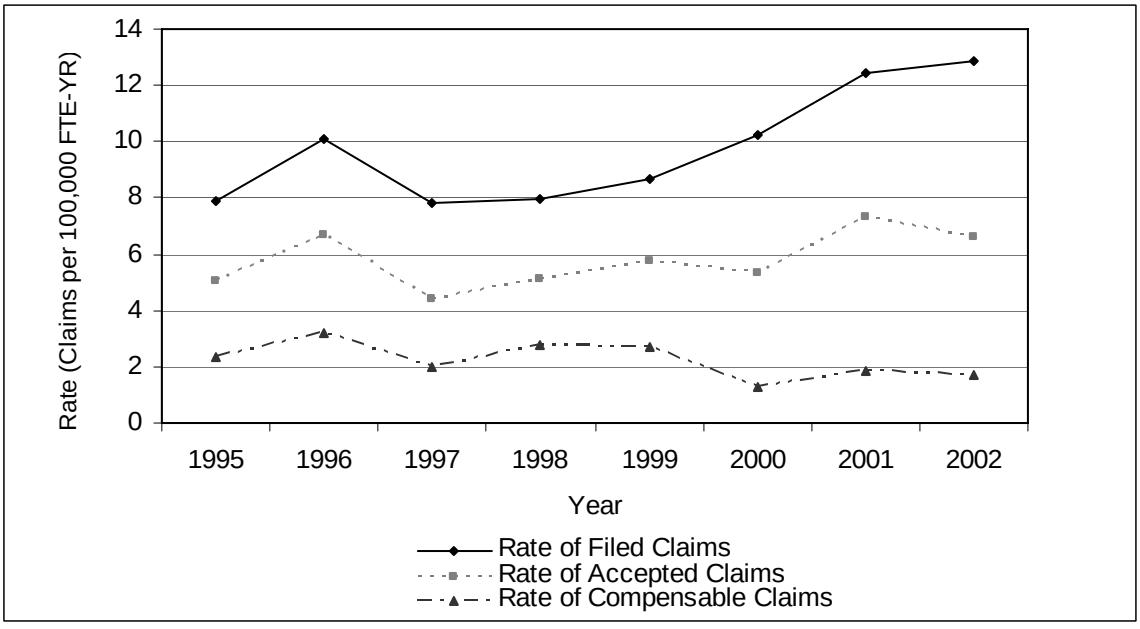
[3] ESSB 6072

In Washington, a study from the Washington State Department of Labor and Industries (L&I)[Error! Bookmark not defined.] documented a total of 1,377 claims for compensation for work-related asthma received by L&I from 1995 to 2002. Approximately 59% of the claims were accepted as valid. Over half the claims were filed by women, and claimants ranged in age from 15 to 77 years, with an average age of 41 years.

To be accepted (and compensated), claims must meet the following criteria: (1) a physician must give opinion that it is a probable (greater than 50%) that work conditions are the cause of illness or have aggravated a pre-existing condition; (2) objective medical findings must support the diagnosis; and (3) the disease must arise directly out of employment. Information about the cost of claims was presented in Chapter II of this report.

The rate of total claims increased significantly from 7.9 to 12.9 per 100,000 full-time employee (FTE) during this time period (see Figure 81). The rate of accepted claims also increased from 5.0 to 6.6 per 100,000 FTE. This suggest that incidents of work-related asthma are increasing, which may reflect (or contribute to) the increase in the population prevalence of asthma among adults. These estimates are likely an underestimate, because work-related asthma is generally thought to be under recognized and underreported to the workers' compensation system. Further, not all workers are covered by the workers' compensation state fund, such as federal employees and the self-employed.

Figure 9: Trends in work compensation claims for asthma, Washington State



Source: Labor & Industries Worker Compensation Claims Data. Curwick, et al.[Error! Bookmark not defined.]

Diverse work environment and worker exposures were represented among the claims reported. Worksites included in claims were sawmills, plastics, wood, and fiberglass products manufacturing, office environments for clerical workers, and medical clinics.

Exposures included paint or painting compounds; flame or smoke; infection or parasitic agents (including mold); wood dusts; and other unidentified or unclassified particles or chemicals. Workers affected were laborers, trade workers, farm workers, managers and administrators, and retail or personal sales workers.

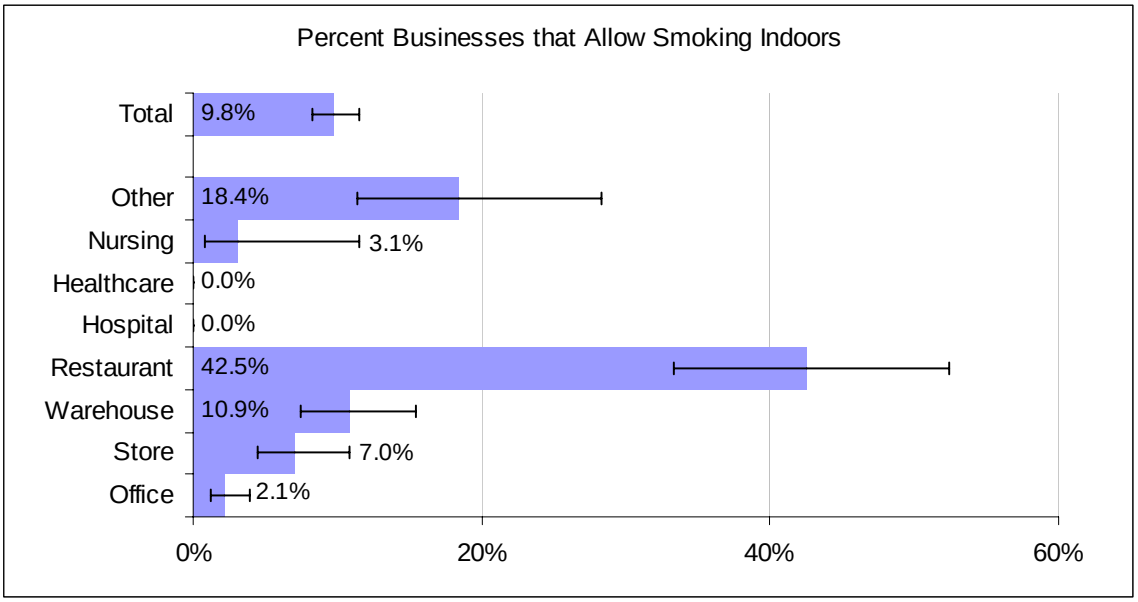
These trends suggest an increasing incidence of work-related asthma claims in Washington. The authors of the Labor and Industries report mention the contrast between this trend and the declining claim incidence rates for other types of occupational illnesses and injuries. Clearly, prevention efforts for work-related asthma are a priority, and multiple industries and exposures must be targeted.**Error! Bookmark not defined.**

Workplace Indoor Air

As indicated previously, there are diverse possibilities for occupational exposures that put workers at risk for asthma. Exposure types are related to specific job conditions and equipment or materials. The wide variety of worksites and exposures makes development of effective safety measures and education of worksite managers challenging.

One exposure present in a variety of worksites is secondhand smoke. State law bans smoking in most workplaces (Chapter 70.94 RCW, Washington State Clean Indoor Air Act) but restaurants, bars, casinos, and some other worksites are currently exempted from that ban. A recent survey of large worksites in Washington found that about 43% of restaurants allow smoking, as well as 11% of warehouses, one in five mixed businesses (including agricultural and industrial facilities), and a small proportion of nursing homes (see Figure 82). A few casinos and bar/pubs were also randomly selected as part of the survey, and although their small number (N=20) prevents generalization to casinos and bars statewide, all of those interviewed (100%) allowed smoking indoors. Worksites such as restaurants, bars, and casinos are of particular interest because the visiting public may be exposed to smoke the same as the workers.

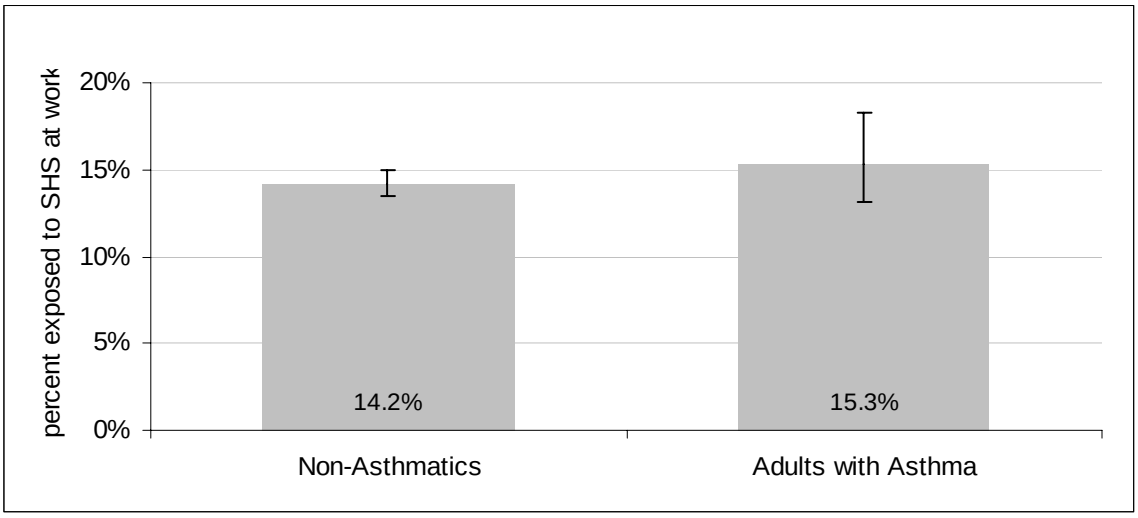
Figure 10: Prevalence of rules allowing indoor smoking by worksite type, among large Washington worksites



Source: 2004 Washington State Worksite Policy Survey, employers with 50+ employees only.

People with asthma should avoid secondhand smoke exposure (as well as smoking) as part of a good asthma control plan. This suggests that people with asthma (non-smokers) should avoid working in environments where they are exposed to secondhand smoke on the job. There was no difference in self-reported occupational exposure to secondhand smoke between people with asthma and people who do not have asthma (see Figure 83). It is possible that people with asthma are more sensitized to exposure, and over-report their exposure in comparison to people without asthma. Alternatively, given that asthma is most prevalent among the least educated people, it is possible that people with asthma are not able to select among jobs for one where they are not exposed.

Figure 11: Prevalence of exposure to secondhand smoke (SHS) at work by asthma status, among Washington adult non-smokers



Source: 2003 Washington State Behavioral Risk Factor Surveillance System (BRFSS).

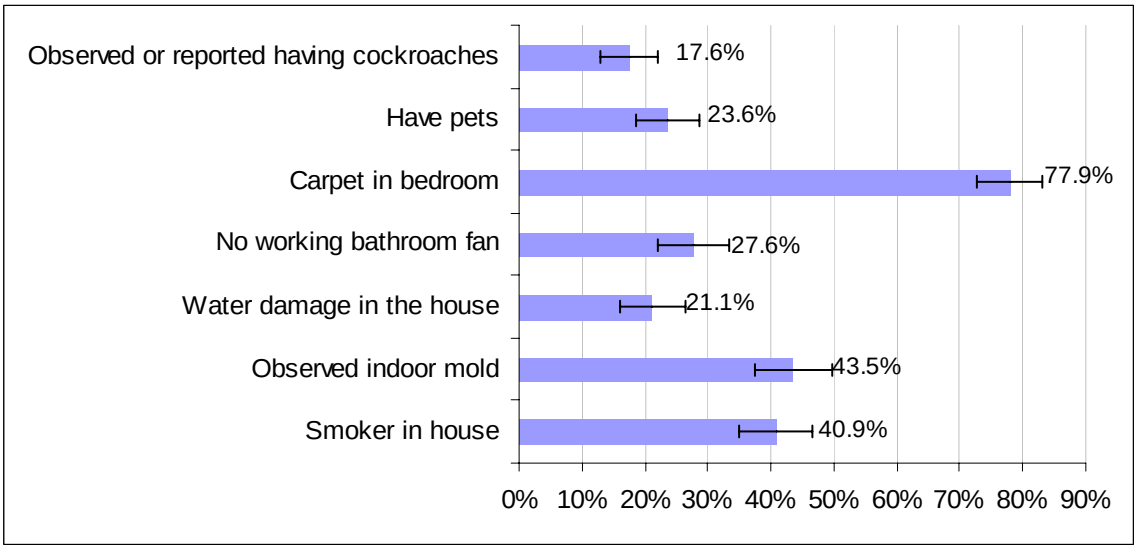
D. Homes

Individual homes are one place where people with asthma and their families can assure the safest environment possible. Homes can include a variety of structures, such as private houses, group houses, apartments, mobile homes, or institutional homes.

Given that asthma is associated with low income, it may be of particular importance for administrators of group or public housing facilities to assure that group homes or public housing environments are safe and free from asthma-related exposures. Home-based childcare businesses can serve large numbers of children over time, and given that children are particularly vulnerable to developing asthma or asthma exacerbation from home exposures it is important to assure that childcare providers are aware of what they can do to make their homes as safe as possible for those children.

Washington State does not have data to describe general household triggers among people with asthma statewide or to describe to what extent Healthy People objectives for clean home environments are being met; however, a study conducted among low-income residents in King County[xxxix xl] provides some suggestion that the level of exposure to home triggers among people with asthma is high. This study was conducted among a low income group of people with asthma. Prior to an intervention to educate people with asthma about things they can do in the home to reduce common triggers, an assessment of the existence of those triggers was conducted. About one in five people with asthma in the study reported exposure to cockroaches and/or water damage; about one in four had pets and/or did not have a working bathroom fan; two out of five had indoor mold and/or were exposed to cigarette smoke indoors; and nearly eight out of ten had carpet in their bedrooms (see Figure 84).

Figure 12: Baseline prevalence of home triggers for asthma, among Seattle-King County asthma study participants



Source: Seattle-King County Healthy Homes Project[xli]

These data are from a high-risk (low income) population groups. For low income people, structural or building-related risk factors, such as physical defects in an apartment, may be outside of their individual control. The repairs required to prevent cockroaches from entering a home, or water damage, or removal of carpet, may be too expensive or not possible for renters to complete. Changing those risk factors may require more community-level interventions to support structural improvements in existing or new high-risk housing.

Some of these factors, such as pets and home smoking, can be addressed through policies at group housing facilities (such as apartments or dormitories). Others factors may be better addressed by increasing knowledge among individuals about managing their home environment. For example, baseline data from a pilot project conducted in the Yakima region indicated that while about two-thirds of families that had a child with asthma did vacuum at least weekly (67%) and keep stuffed toys and furniture to a minimum (64%), only one-third (32%) banned pets from the child's room and very few (5%) had pillow and mattress covers to prevent exposure to dust mite allergen.[xlii]

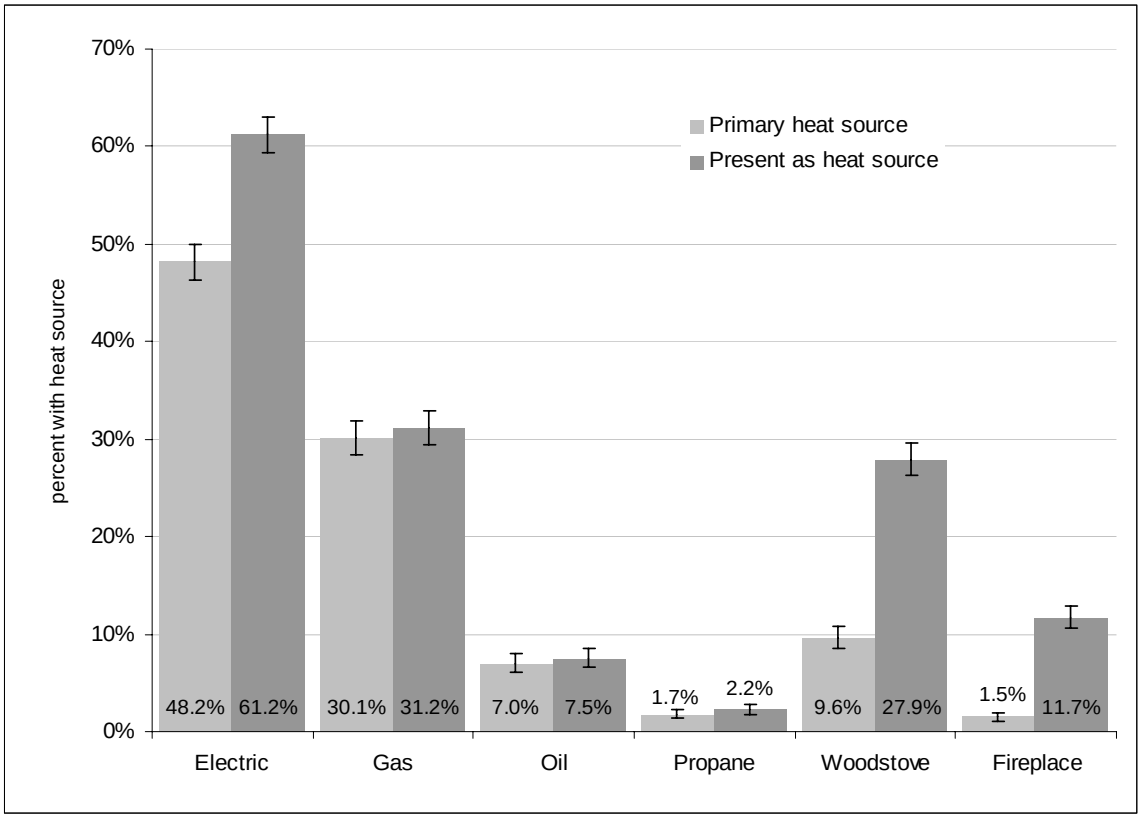
The findings suggest that people with asthma may need to be educated about things to do in their homes to reduce exposure to asthma triggers, such as appropriate cleaning for mold or reducing exposure to cockroaches in order to complement physical facility interventions.

Home Heating Sources

People can inadvertently create unhealthy homes by using heating sources that generate pollutants. For example, woodstoves and fireplaces can generate gases and particulate matter (PM) that exacerbate asthma. Almost one in three Washington homes has a woodstove and more than one in ten has a fireplace (see Figure 85). These are not

frequently indicated as the primary heat source for the home, which could suggest that when they are operated they are less functional (such as uncertified woodstoves, not carefully maintained) and thus potentially even more hazardous to those living in the home.

Figure 13: Prevalence of heat sources in home (primary or available sources), among Washington adults



Source: 1996 BRFSS

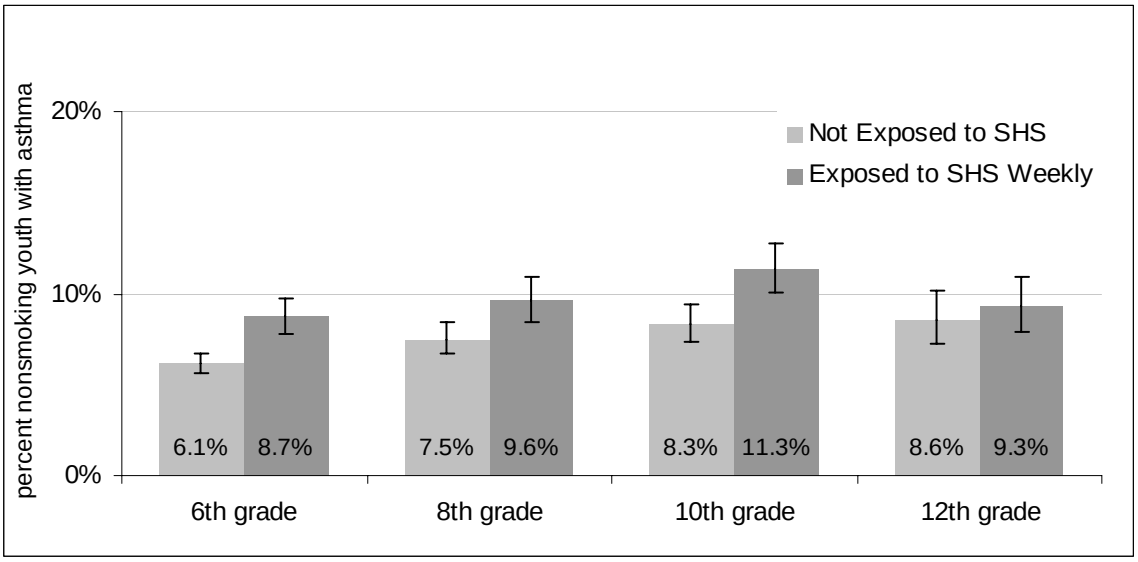
Secondhand Smoke

A common home exposure that is related to both asthma and low income status is secondhand smoke (SHS) – smoke from other people's cigarettes, pipes, or cigars. In Washington, exposure to SHS was significantly associated with greater asthma prevalence among non-smoking youth in 6th, 8th, and 10th grades in Washington (see Figure 86, $p<.001$ for 6th grade; $p=.007$ for 8th grade; $p<.001$ for 10th grade). For example, asthma prevalence among 6th graders who were not exposed to SHS was about 6%, while among youth who were exposed to SHS the asthma prevalence was about 9%. About one in ten youth with asthma overall reported being exposed to SHS during the past week.

Many studies have documented that parental smoking is associated with an increased risk of asthma development in children. In two large reviews of parental smoking and school-aged children,[xliii] [xliv] authors documented that parental smoking (by either parent) was associated with approximately 20% to 40% increased prevalence of asthma, which increased with the number of smokers in the home. Maternal smoking appeared to have a

greater association with asthma than paternal smoking, however paternal smoking alone was still a significant risk factor. Another review of ten papers**Error! Bookmark not defined.** which looked at asthma onset, reported combined increased risks of 31% for children under age six, and 13% for those over six.

Figure 14: Prevalence of asthma by exposure to secondhand smoke (SHS) at home, among non-smoking Washington youth



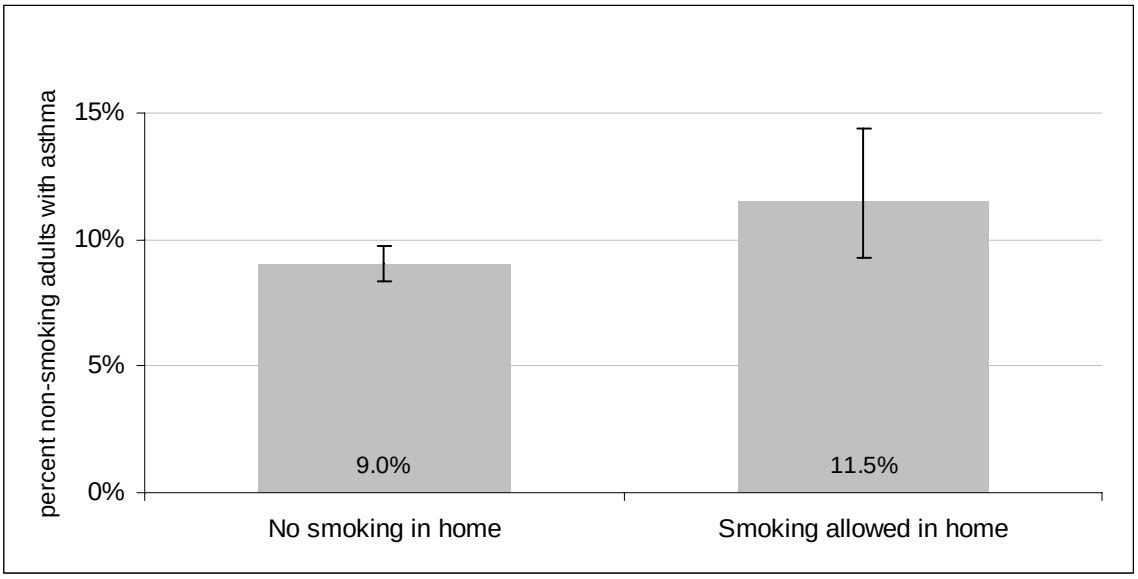
Source: 2002 and 2004 combined Washington State Healthy Youth Survey (HYS).

More than 40,000 children five and under in Washington State are estimated to be exposed to SHS in their homes. Of these children, approximately 500 new cases of asthma occurred each year as a result of the home exposure.[4]

There was no association between exposure to SHS at home and asthma for non-smoking Washington adults (see Figure 87). About one in ten non-smoking adults (regardless of asthma status) reported being exposed to SHS at home.

[4] see technical notes for calculation detail

Figure 15: Prevalence of asthma by exposure to secondhand smoke (SHS) at home, among non-smoking Washington adults



Source: 2003 Washington State Behavioral Risk Factor Surveillance System (BRFSS)

Although the differences were not significant for adults by asthma status, the data suggest a need to educate people with asthma and their families about the importance of not allowing smoking in the home.

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i Etzel RA. How environmental exposures influence the development and exacerbation of asthma. Pediatrics. July 2003;112(1):233-39.

ii Luginaah IN, Fung KY, Gorey KM, Webster G, Wills C. Association of ambient air pollution with respiratory hospitalization in a government-designated "area of concern": the case of Windsor, Ontario. EHP 2005;113(3): 290-296.

iii Yang Q, Chen Y, Shi Y, Burnett RT, McGrail KM, Krewski D. Association between ozone and respiratory admissions among children and the elderly in Vancouver, Canada. Inhalation Toxicoly 2003;15(13): 1297-13208.

iv Yu O, Sheppard L, Lumley T, Koenig JQ, Shapiro GG. Effects of ambient air pollution on symptoms of asthma in Seattle –Area children enrolled in the CAMP study. EHP 2000;10812) 1209-1214.

v Norris G, Larson T, Koenig J, Clairborn C, Sheppard L, Finn D. Asthma aggravation, combustion, and stagnant air. Thorax 2000;55:466-470.

vi Slaughter JC, Lumley T, Sheppard L, Koenig JQ, Shapiro GG. Effects of ambient air pollution on symptom severity and medication use in children with asthma. Ann Allergy Asthma Immunol 2003; 91: 346-353.

vii Peel JL, Tolbert PE, Klein M, Metzger KB, Flanders WD, Todd K, Mulholland JA, Ryan PB, Frumkin H. Ambient air pollution and respiratory emergency department visits. Epidemiology 2005;16(2): 164—174.

viii Avol EL, Gauderman WJ, Tan, SM, London SJ, Peters JM. Respiratory effects of relaocting to areas of differing air pollution levels. Am J Crit Care Med 2001;164: 2067-2072.

ix McConnell R, Berhane K, Filliland F, London SJ, Vora H, Avol E, Gauderman WJ, Margolis HG, Lurmann F, Thomas DC, Peters JM. Air pollution and bronchitic symptoms in Southern California children with asthma. Environmental Health PErspctives. Sepbember 1999;107(9):757-60.

x Yu O, Sheppard L, Lumley T, Koenig JQ, Shapiro GG. Effects of Ambient Air Pollution on Symptoms of Asthma in Seattle – Area children enrolled in the CAMP study. Environmental Health Perspectives. Dec 2000;108(12):1209-1214.

xi Gauderman WJ, McConnell R, Gilliland F, London S, Thomas D, Avol E, Vora H, Berhane K, Rappaport EB, Lurmann F, Margolis HG, Peters J. Association between air pollution and lung function grown in Southern California Children. Am J Respir Crit Care Med. 2000;162:1383-90.

xii Avol EL, Gauderman WJ, Tan SM, London SJ, Peters JM. Respiratory effects of relocating to areas of differing air pollution levels. Am J of Respiratory and Criitcal Care Medicine. December 2001;164(11):2067-72.

xiii McConnell R., Berhane K, Gilliland F, London SJ, Islam T, Gauderman WJ, Avol E, Margolis HG, Peters JM. Asthma in exercising children exposed to ozone: a cohort study. Lancet. 2002;359:386-91.

xiv Gauderman WJ, Gilliland GF, Vora H, Avol E, Stram D, McConnell R, Thomas D, Lurman F, Margolis HG, Rappaport EB, Berhane K, Peters JM. Association between air pollution and lung function growth in southern California children. American Journal of Respiratory and Critical Care Medicine 2002;166: 76-84.

xv Tolbert PE, Mulholland JA, MacIntosh DL, Xu F, Devine DD, Carlin BP, Klein M, Dorley J, Butler AF, Nordenberg DF, Frumkin H, Ryan PB, White MC. Air quality and pediatric emergency room visits for asthma in Atlanta, Georgia. Am J Epidemology. 2000;151(8):798-810.

xvi Sheppard L, Levy D, Norris G, Larson TV, Koenig JQ. 1999 Effects of ambient air pollution on nonelderly asthma hospital admissions in Seattle, WA, 1987-1994. Epidemiology 10:23-30

xvii Environmental Protection Agency "Air Now" http://www.epa.gov/airnow/

xviii Institute of Medicine. Damp Indoor Spaces and Health. Washington DC: National Academies Press; 2004. Available online at http://www.nap.edu/catalog/11011.html.

xix Abulhosn RS, Morray BH, Llewellyn CE, Redding GJ. Passive smoke exposure impairs recovery after hospitalization for acute asthma. Arch Pediatr Adolesc Med 1997;151:135-9.

xx Strachan DP, Cook DG. Parental smoking and childhood asthma: longitudinal and case-control studies. Thorax 1998;53:204-212.

xxi Greer JR, Abbey DE, Burchette RJ. Asthma related to occupational and ambient air pollutants in nonsmokers. J Occup Med 1993;35:909-15.

xxii Ng TP, Hui KP, Tan WC. Respiratory symptoms and lung function effects of domestic exposure to tobacco smoke and cooking by gas in non-smoking women in Singapore. J Epidemiol Community Health 1993; 47:454-8.

xxiii Leuenberger P, Schwartz J, Ackermann-Liebrich U, et al. Passive smoking exposure in adults and chronic respiratory symptoms (SAPALDIA Study). Swiss study on air pollution and lung diseases in adults, SAPALDIA team. Am J Respir Crit Care Med 1994;150:1222-8.

xxiv Hu FB, Persky V, Flay BR, Zelli A, Cooksey J, Richardson J. Prevalence of asthma and wheezing in public schoolchildren: association with maternal smoking during pregnancy. Ann Allergy Asthma Immunol 1997;79:80-84.

xxv Thorn J, Brisman J, Toren K. Adult-onset asthma is associated with self-reported mold or environmental tobacco smoke exposures in the home. Allergy 2001;56:287-92.

xxvi Jaakkola MS, Piipari R, Jaakkola N, Kaakkola JJK. Environmental tobacco smoke and adult-onset asthma: a population-based incident case-control study. Am J Public Health 2003;93:2055-2060.

xxvii Beckett WS. (2002). Revised Protocol: Criteria for Designating Substances as Occupational Asthmagens on the AOEC List of Exposure Codes. Accessed from: <http://www.aoec.org/Asthmagen_Pro-7-25-02.pdf on January 24>, 2005.

xxviii National Survey of Public Perceptions of Environmental Health Risks – Washington Component. Princeton Survey Research Associates, Pew Charitable Trusts, Georgetown University. 2000. Available at: http://healthyamericans.org/docs/index.php?DocID=18 last accessed 3-12-05.

xxix Washington State Department of Ecology. Washington's Environmental Health 2000. Air Quality. Pub 00-01-003. http://www.ecy.wa.gov/pubs/0001003/index.html (last accessed 6-15-05)

xxx Washington State Department of Ecology. 2000-2002 Air Quality Trends. April 2003. Available at http://www.ecy.wa.gov/pubs/0302008.pdf (last accessed 3-22-05)

xxxi Puget Sound Clean Air Agency. www.pscleanair.org

xxxii Prill R, Blake D, Hales D. School Indoor Air Quality Assessment and Program Implementation. Washington State University and Northwest Air Pollution Authority. Available at: http://www.energy.wsu.edu/projects/building/iaq.cfm (last accessed 6-15-05)

xxxiii Shendell DG, Prill R, Fisk WJ, Apte MG, Blakc D, Faulkner D. Associations between classroom CO2 concentrations and student attendance in Washington and Idaho. Indoor Air. 2004;14:333-341.

xxxiv Washington State Department of Ecology. Washington State Clean School Bus Program, 2005 Report to the Legislature. Available at: http://www.ecy.wa.gov/pubs/0402029.pdf

(last accessed 5-2-05)

xxxv Blanc PD, Toren K. How much adult asthma can be attributed to occupational factors ? American Journal Medicine 1999;107:580-587.

xxxvi Mannino DM. How much asthma is occupationally related? Occupational Medicine 2000; 15:359-68.

xxxvii Schwartz, D.A., and Peterson, M.W. Occupational lung disease. Advances in Internal Medicine 42:269-312, 1997.

xxxviii Venables KM, Chan-Yeung M. Occupational asthma. Lancet. 1997;349:1465-9.

xxxix Krieger JW, Song L, Takaro TK, Stout J. Asthma and the home environment of low-income urban children: preliminary findings from the Seattle-King County healthy homes project. Journal of Urban Health. 2000;77:50-67.

xl Krieger J, Takaro TK, Allen C, Song L, Weaver M, Chai S, Dickey P. The Seattle-King County Healthy Homes Project: implementation of a comprehensive approach to improving indoor environmental quality for low-income children with asthma. Environmental Health Perspectives. 2002;110(S2):311-22.

xli Krieger JW, Takaro TK, Song L, Weaver M. The Seattle-King County healthy homes project: a randomized, controlled trial of a community health worker intervention to decrease exposure to indoor asthma triggers. AJPH. 2005;95(4):652-9. Data provided by Lin Song 12-04 as combined baseline data from both intervention and control groups in this study.

xlii John Thayer. Yakima Valley Farm Workers Clinic, Childhood Asthma Project Coordinator.. Personal communication, 6-05.

xliii Cook DG, Strachan DP. Parental smoking and prevalence of respiratory symptoms and asthma in school age children. Thorax 1997;52:1081-94.

xliv Strachan DP, Cook DG. Parental smoking and childhood asthma: longitudinal and case-control studies. Thorax 1998;53:204-212